

## THE CHROMOSOME COMPLEMENT OF CYPHOMANDRA BETACEA

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*With six text figures*

The genus *Cyphomandra* contains thirty or more species of herbs, shrubs, and small trees, all of which are of South American origin (Bailey, 1925). It is technically distinguished from *Solanum* by the fact that the two cells of the anther are separated by a thickened connective, which appears as a ridge on the back of the anther.

*Cyphomandra betacea* (Cav.) Sendt., the so-called "Tree Tomato," is cultivated, to a certain extent, by the natives of the American tropics for its edible fruit. It was first described in 1801 under the name *Solanum betaceum* Cavanilles. Later it was placed in the genus *Cyphomandra* by Sendtner (1845).

In the course of an investigation of the chromosome number and behavior of various members of the Solanaceae, several plants of *C. betacea* were made available to the writer through the courtesy of Professor Karl Sax. A preliminary examination indicated that the meiotic divisions were irregular, and, for this reason, it was thought that a further cytological examination would contribute some information on the cause and effect of the irregularities noted at meiosis.

Attention was focused on three points: (1) A description of the nature of the irregularities taking place during meiosis; (2) the effect of these irregularities on the amount of pollen sterility; (3) the probable taxonomic relations of *C. betacea* from a study of its cytology.

Observations on the meiotic divisions were made from aceto-carmin smear preparations. Preparations showing microspore divisions are, as a rule, unsatisfactory when prepared by the usual methods, because the pollen grains are thick and opaque. By fixing with aceto-carmin and exerting considerable pressure on the cover slip, combined with gentle heating of the slide, excellent preparations were secured.

*C. betacea* has twelve pairs of chromosomes. The haploid complement is shown particularly well at metaphase of the microspore division (Fig. 1). It is apparent that the attachment constrictions are approximately median in all cases, and there are no conspicuous morphological variations among the individuals of the haploid set. In root tip preparations, twenty-four chromosomes are plainly discernible. The somatic chromosomes are characteristically long and slender. Each



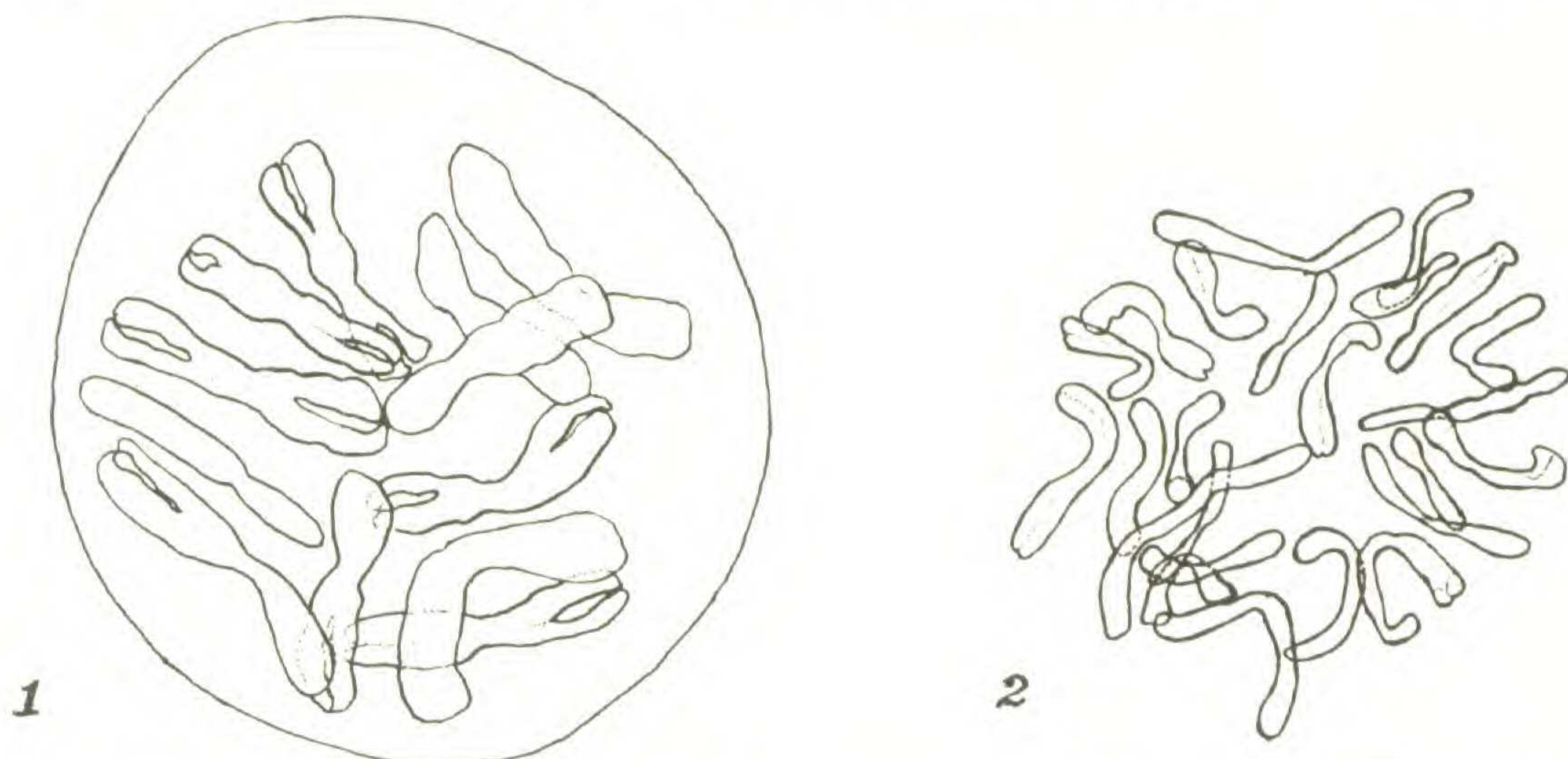


FIGURE 1. THE 12 GAMETIC CHROMOSOMES IN THE FIRST DIVISION OF THE MICROSPORE. — FIGURE 2. THE 24 SOMATIC CHROMOSOMES AT METAPHASE.  $\times 2100$ .

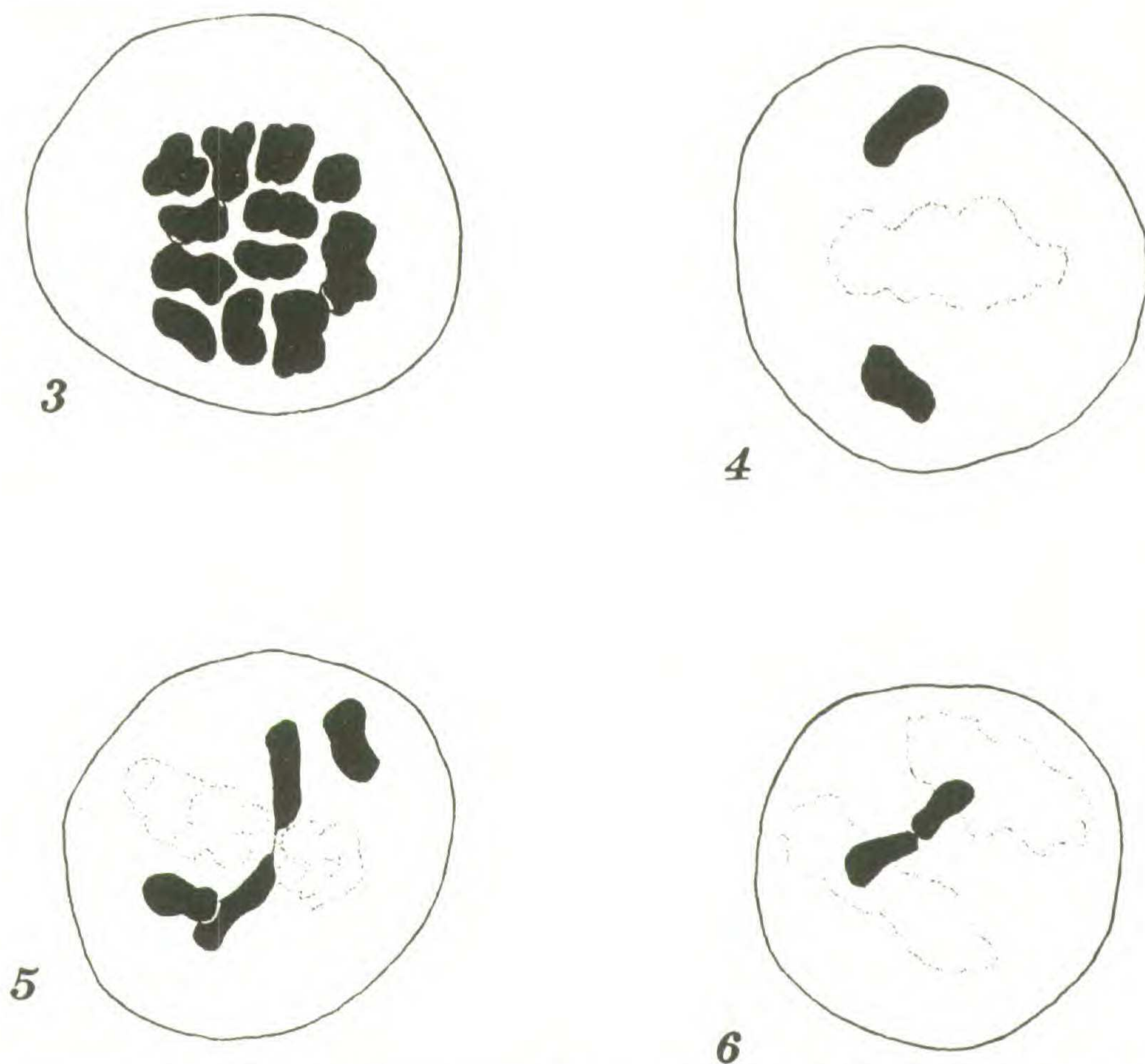


FIGURE 3. THE 12 BIVALENT CHROMOSOMES AT METAPHASE IN THE FIRST DIVISION OF THE POLLEN MOTHER CELL. — FIGURE 4. FIRST METAPHASE SHOWING ONE UNIVALENT AT EACH POLE, THE REMAINDER AT THE EQUATOR. — FIGURE 5. SHOWS THE SAME SITUATION AS IN FIGURE 4 BUT WITH TWO BIVALENTS SHOWING PRECOCIOUS DIVISION. — FIGURE 6. SHOWS A LAGGING PAIR OF CHROMOSOMES.  $\times 2100$ .



chromosome has a median attachment constriction, and several have secondary constrictions (Fig. 2).

Good figures of diakinesis were difficult to obtain, owing perhaps to the unusual amount of chromatin contained in the relatively small nucleus, but where satisfactory figures were examined, it is clear that two of the bivalents have only one terminal chiasma. The remaining bivalents have at least two chiasmata and, in certain cases, as many as three chiasmata.

The structure of the individual chromosomes is very clear at metaphase of the first meiotic division, and the spiral chromonemata are easily visible. At this point several abnormalities were observed to interrupt the ordinary sequence of the meiotic process. Briefly these abnormalities were: (1) One and sometimes two of the univalents were located at each pole, while the remainder of the set were still at the equator (Fig. 4); (2) two pairs of chromosomes frequently showed precocious division (Fig. 5); (3) lagging of one pair of chromosomes was repeatedly observed (Fig. 6). It is estimated that these abnormalities occurred in about 50% of the cases.

The irregularities observed at meiosis are reflected in the pollen, since fully 25% of the pollen grains are aborted. The percentage of aborted pollen in some flowers is much greater, reaching an extreme limit of 50% pollen sterility.

#### DISCUSSION

On comparing the size of the metaphase chromosomes of *C. betacea* with those of *Solanum Capsicastrum* (arbitrarily selecting *S. Capsicastrum* as a representative of the other Solanaceae), it was found that the chromosomes of *C. betacea* averaged slightly over twice as long as those of *S. Capsicastrum* in similar preparations at the same stage. This same relationship existed regarding the width of the chromosomes. The diameters of the pollen mother cells of *C. betacea* and *S. Capsicastrum* stand in the ratio of 1:1.33. Thus the volume of the pollen mother cells of *C. betacea* is approximately three times that of *S. Capsicastrum*.

Vilmorin and Simonet (1928) have reported the chromosome number of a considerable range of solanaceous plants. In their studies they have found an arborescent species of *Solanum* (*S. glaucum*) whose chromosome complement consists of twelve large, irregularly shaped chromosomes. This is the only species of the Solanaceae yet reported where the individual chromosomes approach in size those of *C. betacea*.

Aside from the striking difference in the size of the chromosomes and pollen mother cells, *C. betacea* is very similar, cytologically, to other



members of the Solanaceae. The closely related genera *Salpichroa*, *Solanum*, and *Lycopersicum* all have a basic number of twelve chromosomes and ring bivalents. In this connection it is interesting to note that although the individual chromosomes of *C. betacea* are considerably larger, both in width and in length than those of other species of Solanaceae, the type of association is identical with that found in species with smaller chromosomes.

The amount of pollen sterility (25%) found in *C. betacea* is quite unusual in a pure species, although by no means exceptional. Professor Jack, of the Arnold Arboretum, informs me that *C. betacea* is considered a good species and that it is quite unlikely that it could have hybridized with any other member of the genus, as it is very distinct from other species of *Cyphomandra*. Therefore the irregularities at meiosis and high pollen sterility cannot be accounted for by assuming that the plants under consideration were a direct result of hybridization with a closely related species.

It has been suggested that the irregularities under consideration might be due to the fact that the plants were grown under a lower temperature than that to which they are accustomed in their native habitat. Acting on this suggestion, the writer has examined pollen of plants from Cuba. (This pollen was supplied through the kindly cooperation of Mr. R. M. Grey of the Atkins Institution of the Arnold Arboretum.) Pollen sterility of the Cuban plants averages approximately 5%, compared with an average sterility of 25% of plants flowering at the Bussey Institution. It appears as if this considerable difference in pollen sterility is significant, particularly since the pollen sterility was as high as 50% in a few cases of the plants grown under different environmental conditions.

There is good evidence that meiosis in plants is, in some measure, disturbed by lowering of the temperature. Belling (1925) first suggested that pairing of the chromosomes might be more easily disturbed by cold in tropical or subtropical plants than would be the case with plants of temperate regions. He has also suggested that cold treatment might be an important means of inducing tetraploidy in tropical plants. Sax (1931) kept plants of *Rhoeo discolor* at about 45 degrees Fahrenheit for several days. The pollen mother cells of these plants showed a complete lack of pairing of the chromosomes at the first meiotic division. When the cold treated plants were again placed under normal conditions, the ordinary meiotic behavior was restored.

Since the plants of *C. betacea* were not critically tested in a similar manner to find out if the temperature was the factor responsible for the



pollen sterility observed, it is impossible to state with certainty that temperature was the environmental variable.

However, what little evidence available is highly suggestive and indicates that the irregularities during meiosis are directly traceable to the low temperatures prevailing when the plants were examined. The manner in which temperature seems to operate, in this case, is by reducing the number of chiasmata in certain chromosomes, which results in very loose pairing at diakinesis.

This naturally leads to speculation in regard to the way in which plants cope with conditions of decreasing temperature. From the evidence at hand, it seems as though the answer to this question may be that decreasing temperature causes greater variability, which, in turn, increases the chances of a mutant's being produced that would be better able to survive under the new set of conditions.

#### SUMMARY

1. *Cyphomandra betacea* has twelve pairs of chromosomes. The chromosomes of this species are considerably larger than those of any solanaceous plant yet reported.

2. The irregularities which occur during meiosis are discussed, and evidence is brought forth to indicate that these irregularities were due to the temperature conditions prevailing at the time the plants were in flower.

3. Pollen sterility averaging about 25% has been found in the plants examined. This value, when compared with 5% pollen sterility found in plants grown in Cuba, is considered significant and may be attributed to the difference in temperature under which the plants were grown.

4. The indications are that temperature operates on the meiotic division by reducing the number of chiasmata per bivalent in certain chromosomes.

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